

## **SPACE 2013 Abstract**

### **Atmospheric Processing Module for Mars Propellant Production**

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The multi-NASA center **Mars Atmosphere and Regolith COLlector/PrOcessor for Lander Operations** (MARCO POLO) project was established to build and demonstrate a methane/oxygen propellant production system in a Mars analog environment. Work at the Kennedy Space Center (KSC) Applied Chemistry Laboratory is focused on the Atmospheric Processing Module (APM). The purpose of the APM is to freeze carbon dioxide from a simulated Martian atmosphere containing the minor components nitrogen, argon, carbon monoxide, and water vapor at Martian pressures ( $\sim 8$  torr) by using dual cryocoolers with alternating cycles of freezing and sublimation. The resulting pressurized  $\text{CO}_2$  is fed to a methanation subsystem where it is catalytically combined with hydrogen in a Sabatier reactor supplied by the Johnson Space Center (JSC) to make methane and water vapor. We first used a simplified once-through setup and later employed a  $\text{H}_2/\text{CO}_2$  recycling system to improve process efficiency. This presentation and paper will cover (1) the design and selection of major hardware items, such as the cryocoolers, pumps, tanks, chillers, and membrane separators, (2) the determination of the optimal cold head design and flow rates needed to meet the collection requirement of  $88 \text{ g CO}_2/\text{hr}$  for 14 hr, (3) the testing of the  $\text{CO}_2$  freezer subsystem, and (4) the integration and testing of the two subsystems to verify the desired production rate of  $31.7 \text{ g CH}_4/\text{hr}$  and  $71.3 \text{ g H}_2\text{O}/\text{hr}$  along with verification of their purity. The resulting  $2.22 \text{ kg of CH}_4/\text{O}_2$  propellant per 14 hr day (including  $\text{O}_2$  from electrolysis of water recovered from regolith, which also supplies the  $\text{H}_2$  for methanation) is of the scale needed for a Mars Sample Return mission. In addition, the significance of the project to NASA's new Mars exploration plans will be discussed.